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Raster Soil Mapping

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April 18, 2017

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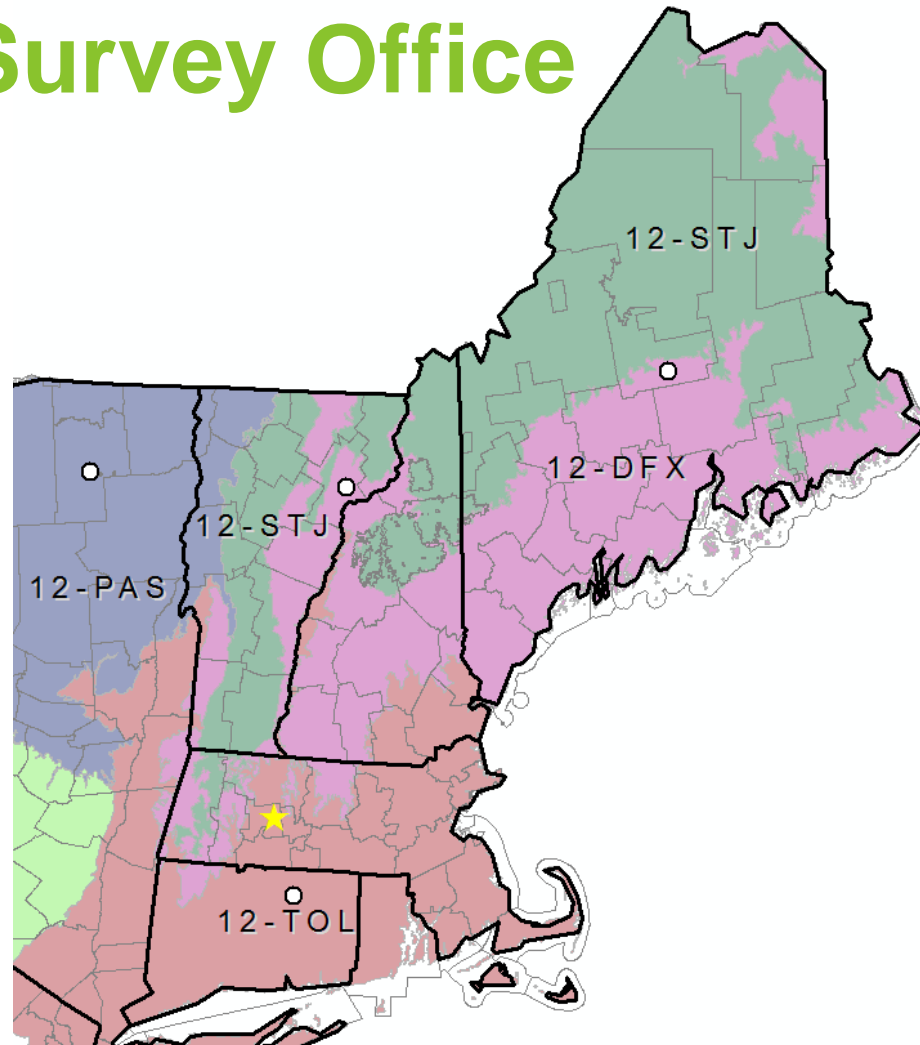
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MLRA Soil Survey Office



Area 12-STJ covers parts of 5 states and dozens of traditional, non-MLRA soil survey areas; about 17 million acres.

Responsible for MLRA 143, Northeastern Mountains (excluding Adirondack region, NY).

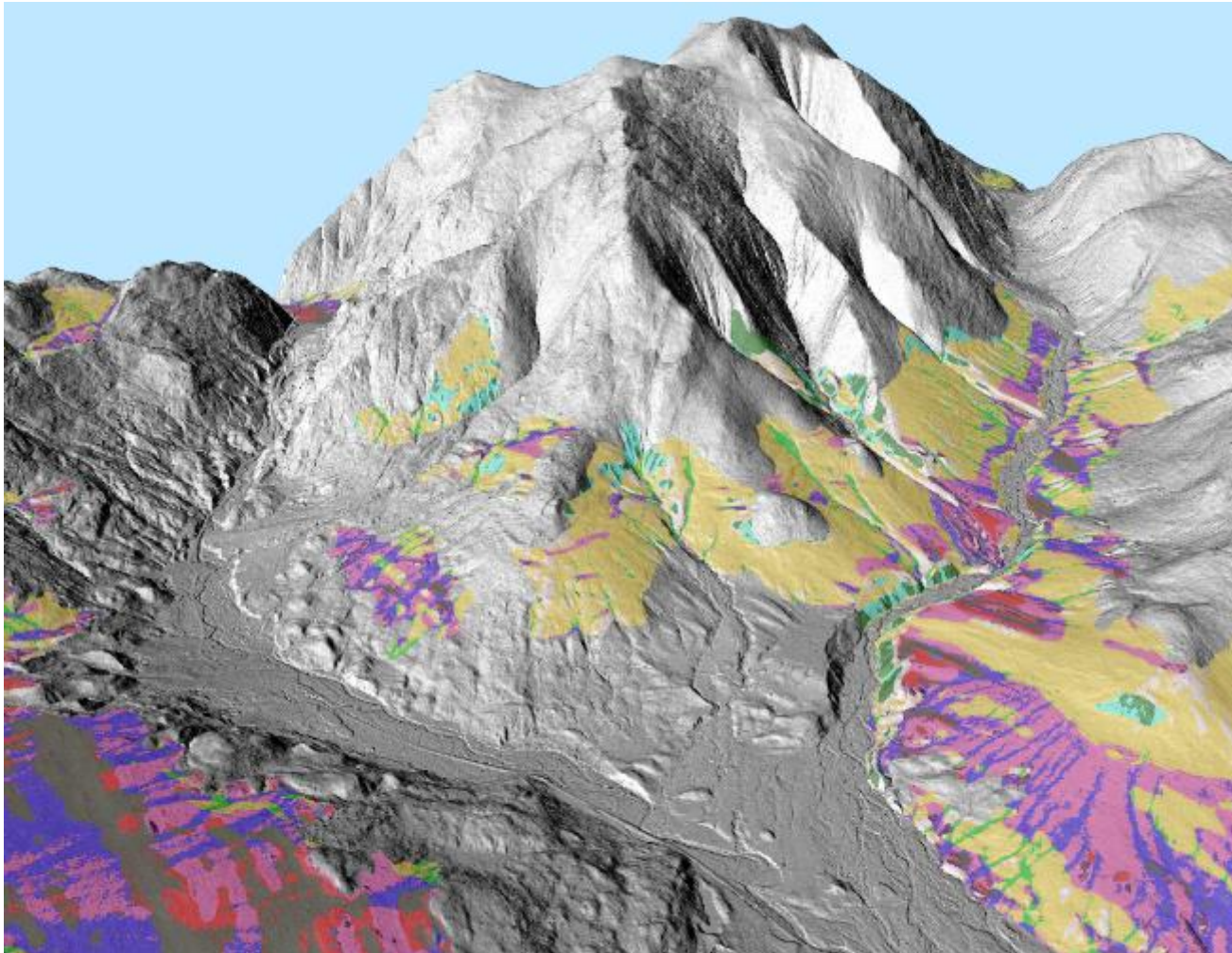


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12-STJ Specialty: knowledge based raster soil mapping



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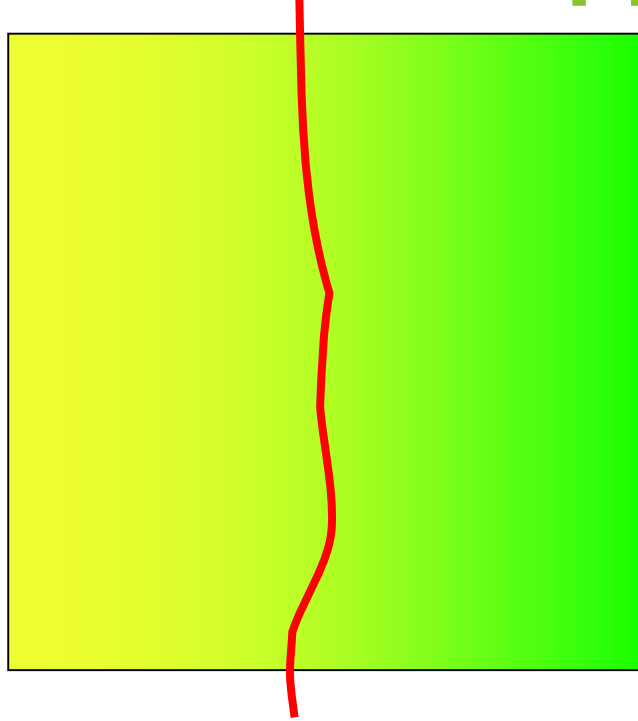
Raster Soil Mapping



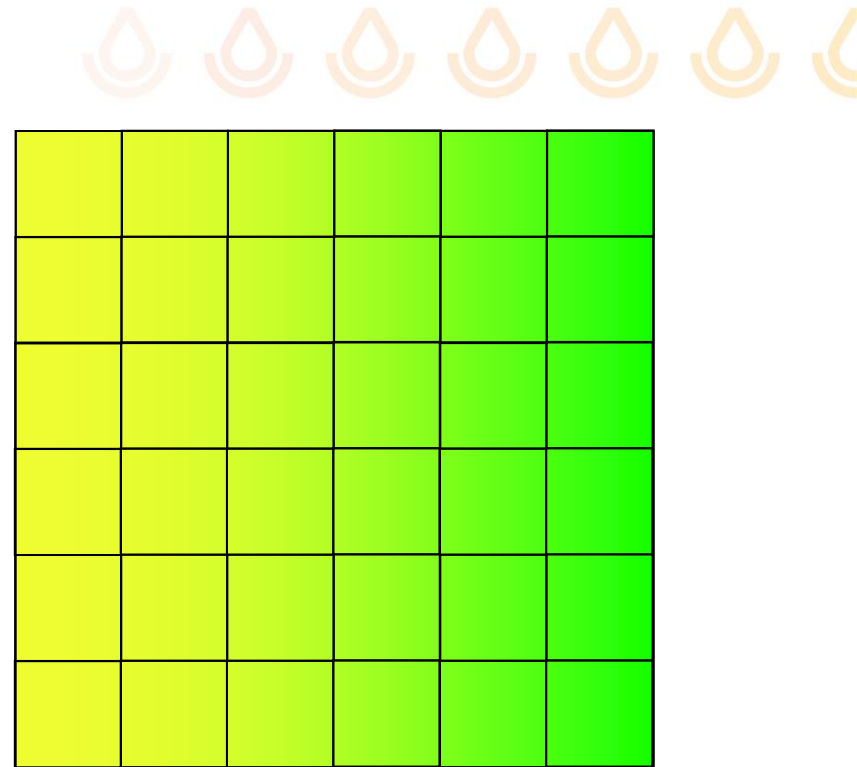
- Digital soil mapping (DSM) is a very broad concept.
- **Knowledge-based Raster Soil Mapping** is a specific approach to DSM



Raster Soil Mapping



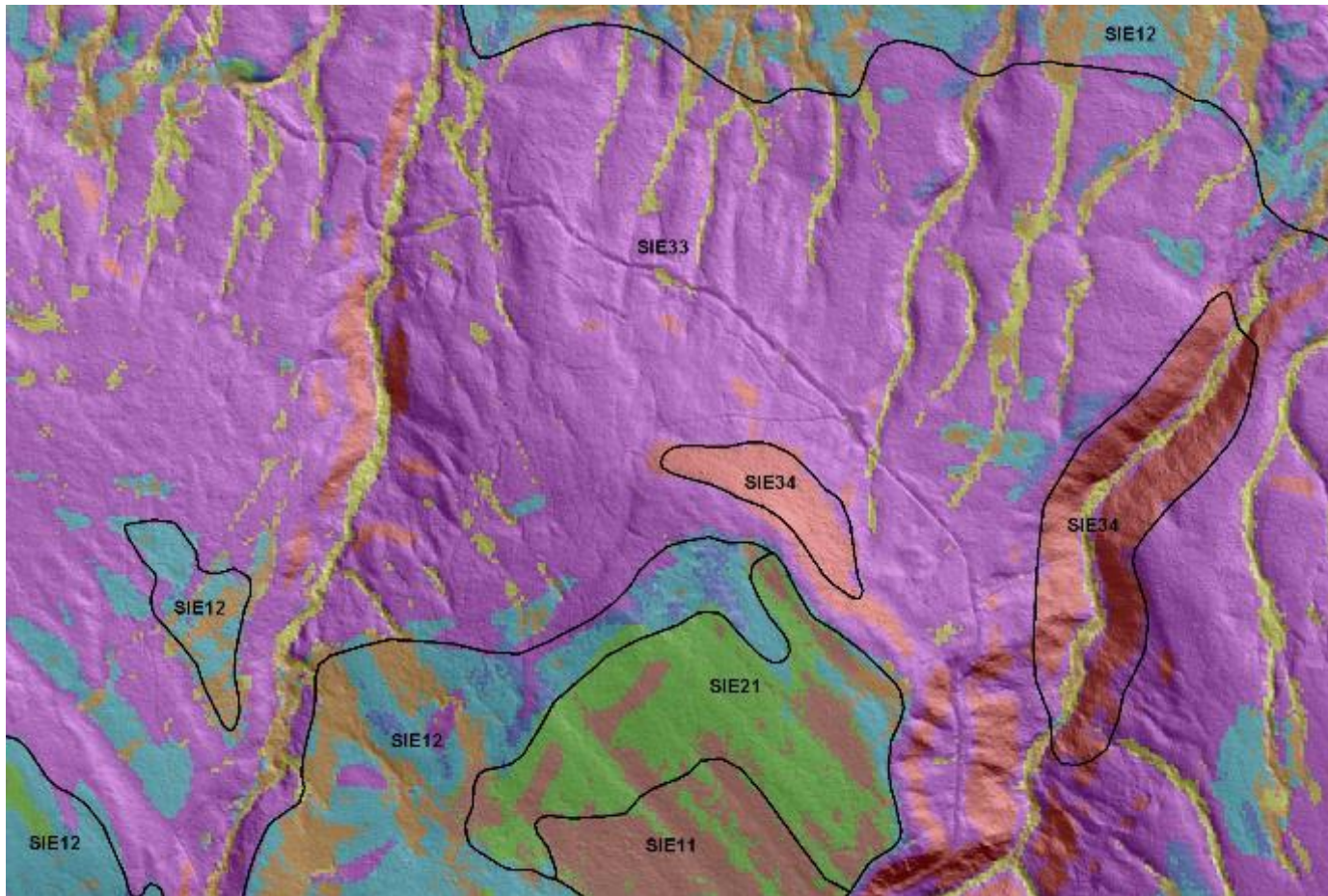
In conventional mapping, the primary question is “Where is the boundary between two soils?” and the focus is on those marginal areas.



In fuzzy mapping, the primary question is “Where is the typical soil for this type?” and the focus is on those “central” areas.



Essex County, VT: first published raster soil survey in the country



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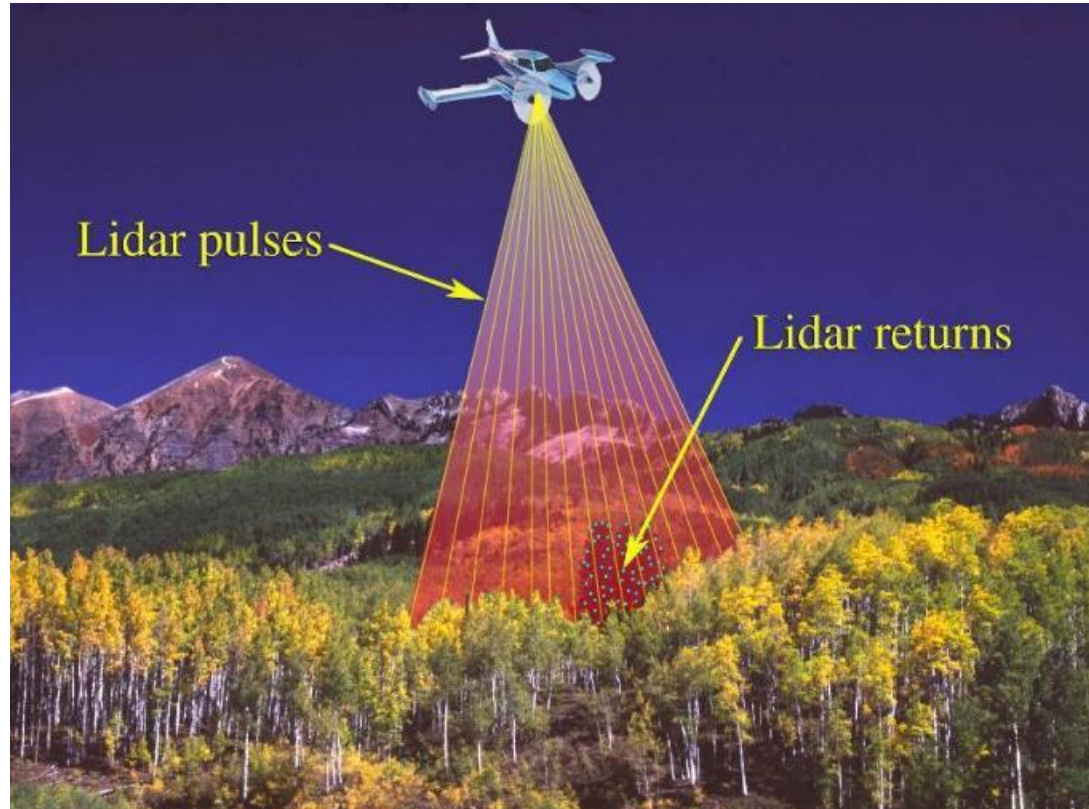
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It all starts with...



Light Detection and Ranging System (LiDAR)



courtesy of the US Geological Survey



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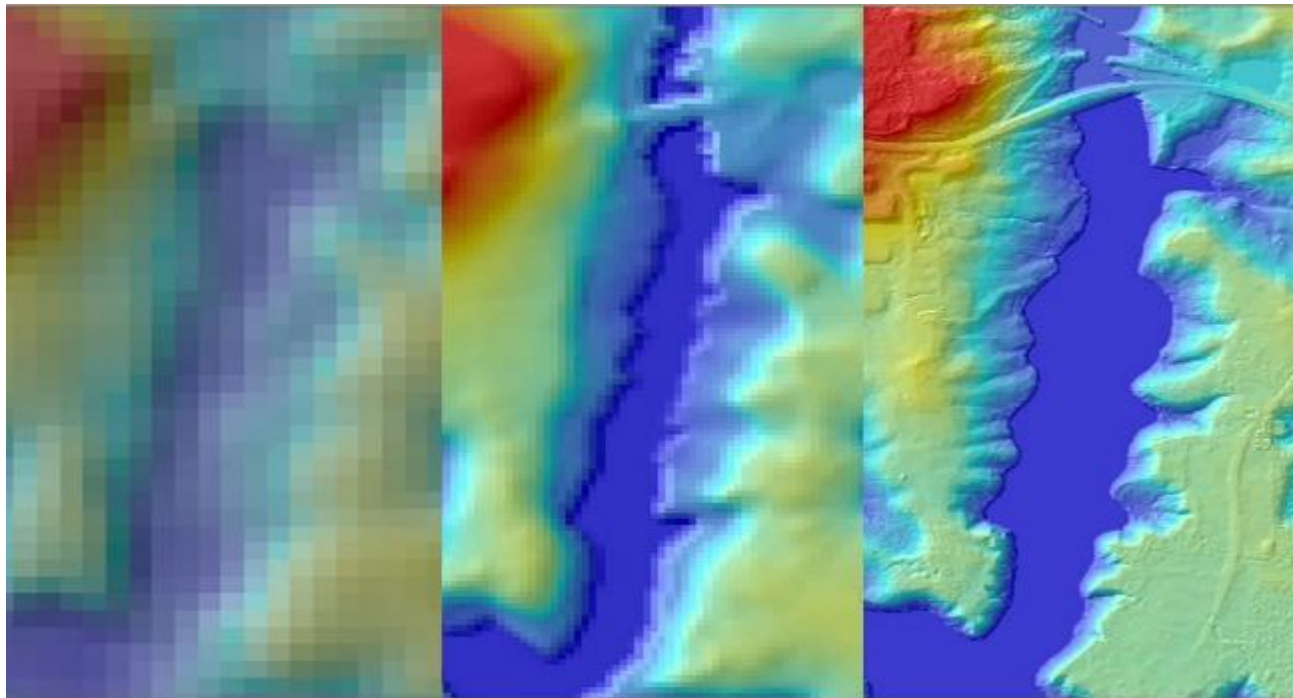
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30-meter DEM

10-meter DEM

1-meter DEM



**Comparison of terrain models for Fresh Creek, Strafford County, NH:
NED 30-meter and 10-meter DEMs versus 1-meter LiDAR**



Visualization & Landscape Stratification



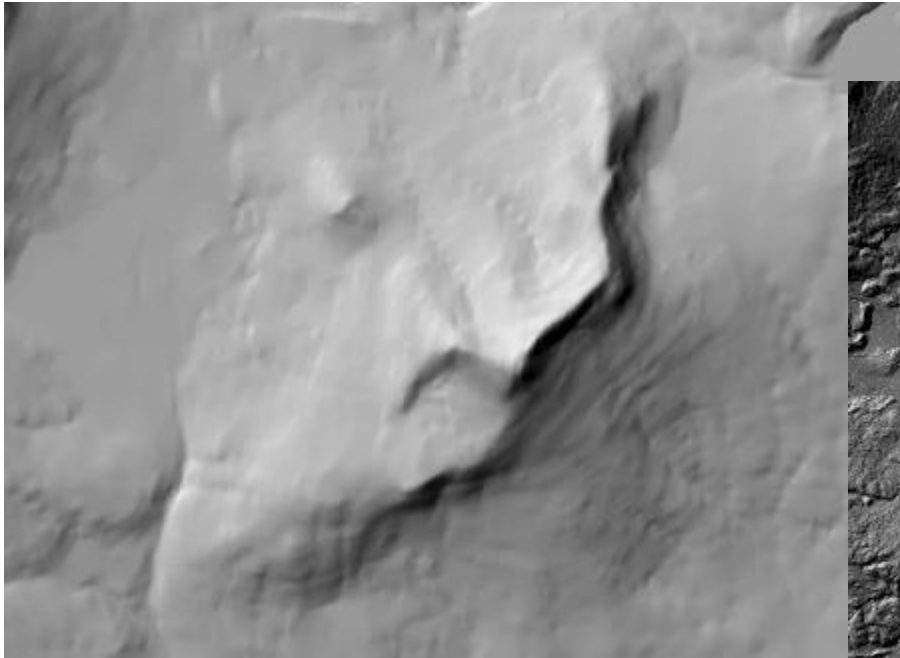
Prior to 2000 and the implementation of GIS in soil survey offices, landscape/landform visualization was via aerial photography and topographic maps.

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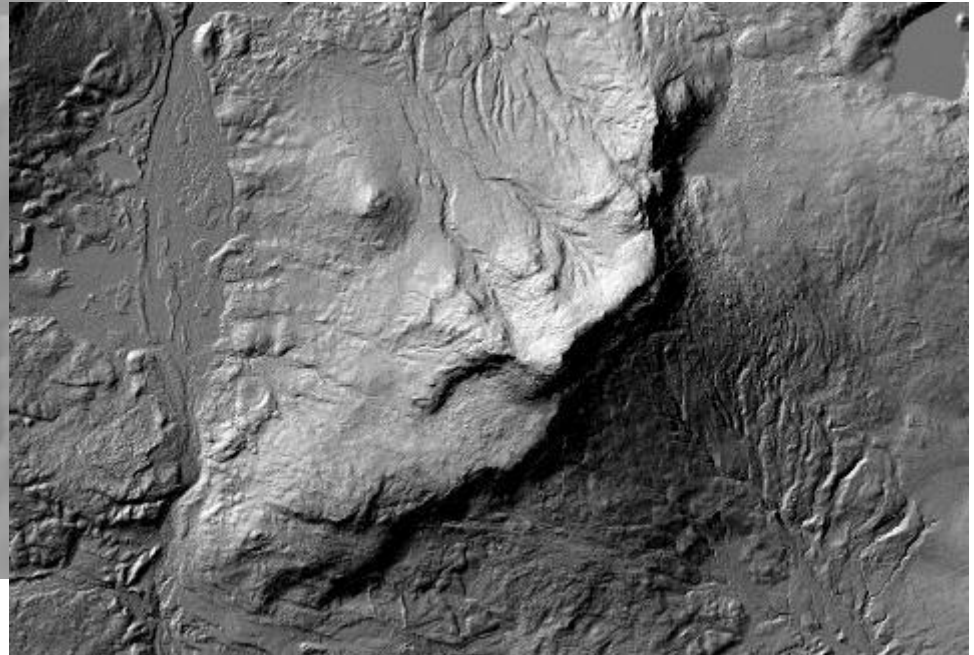


Visualization & Landscape Stratification



Hillshade from USGS 10m DEM

With the implementation of GIS, spatial analysis techniques became more sophisticated. However, inadequate terrain data remains a limiting factor.



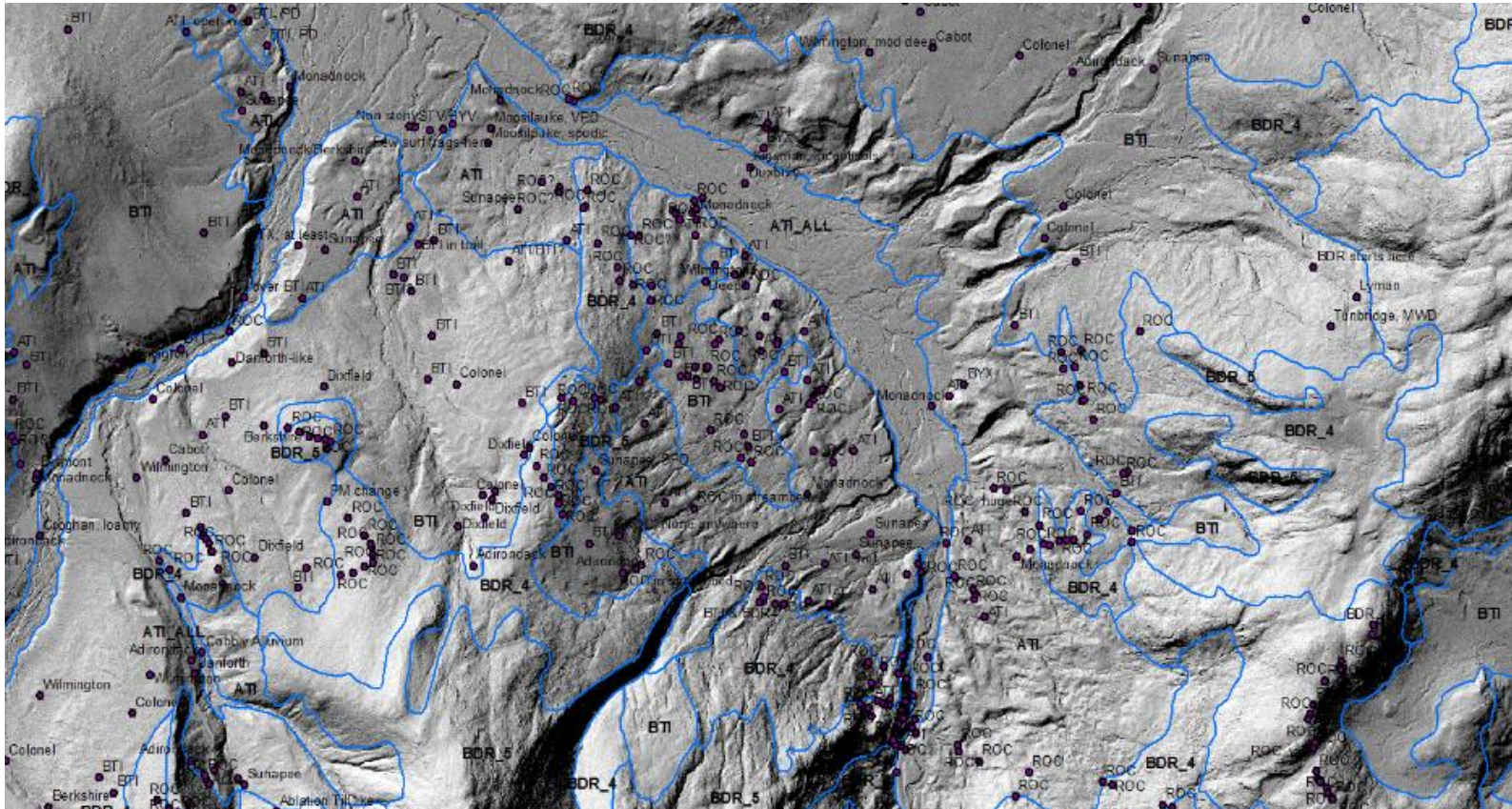
Hillshade from 3m LiDAR DEM

High-resolution elevation data from LiDAR overcomes this limitation.

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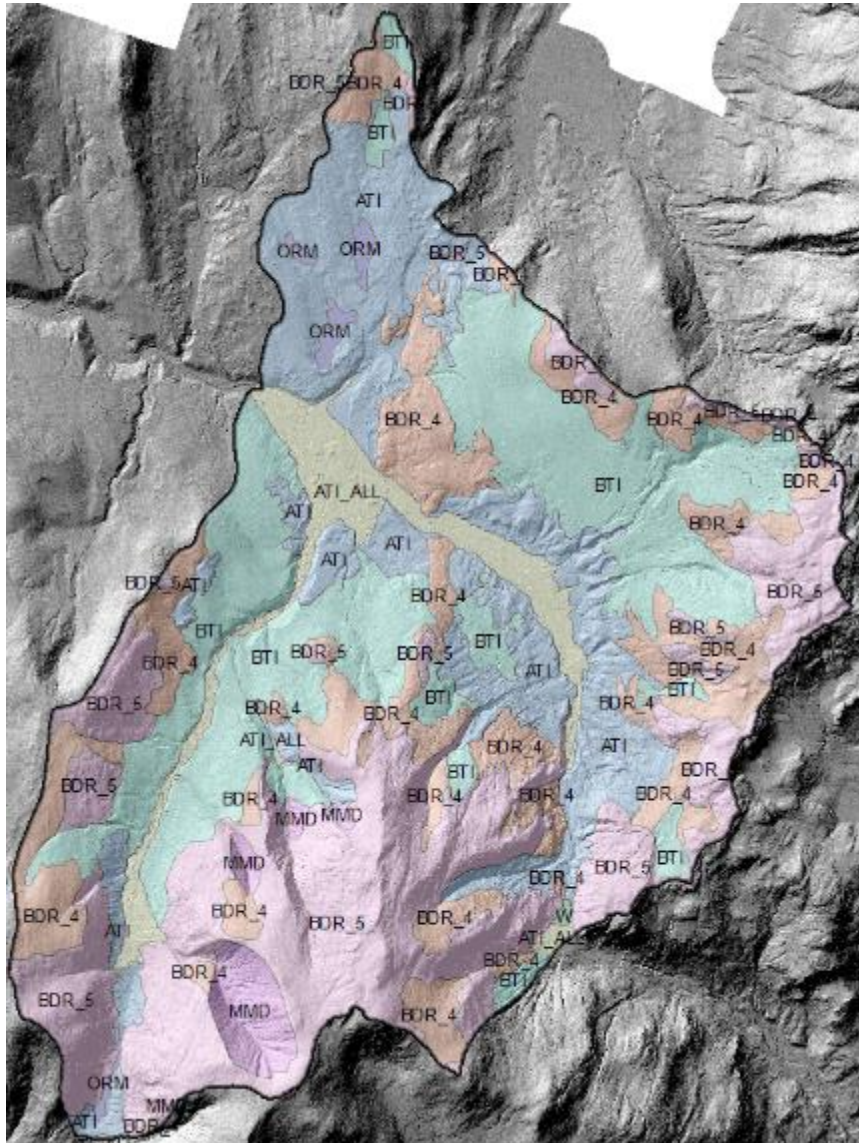


Parent material delineations are thoroughly critiqued and field checked. Field investigations are specifically directed.

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Next step is to further stratify each type of parent material into appropriate soil classes.

These classes could be as narrow as one soil component, but more realistically encompass multiple soil components/series that occur on similar landscape positions.

The Arc Soil Inference Engine (ArcSIE) is used to model the typical soil formative environment for each class.





Poorly Drained



Somewhat Poorly Drained



Moderately Well Drained

The soil classes that make up a given model generally encompass a catena.



Raster Soil Mapping



ArcSIE is a proven tool, designed for *field soil scientists* to implement knowledge-based raster soil mapping.

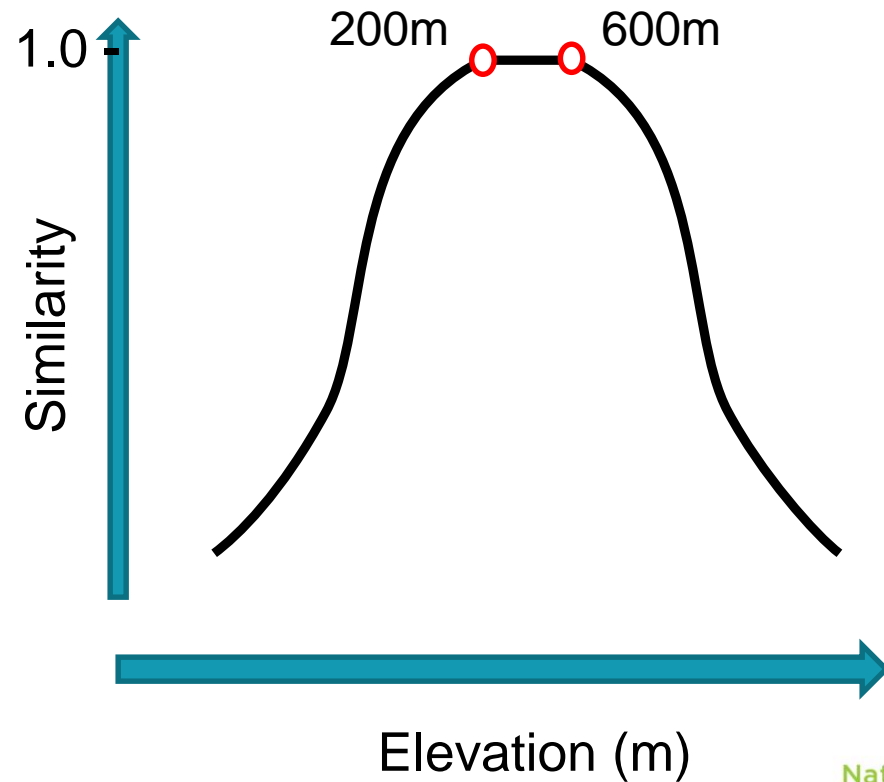
We define the typical soil formative environment in the model, and the resulting fuzzy membership values represent the similarity of the soil at each pixel location to a particular soil series.



Knowledge Represented as a Rule

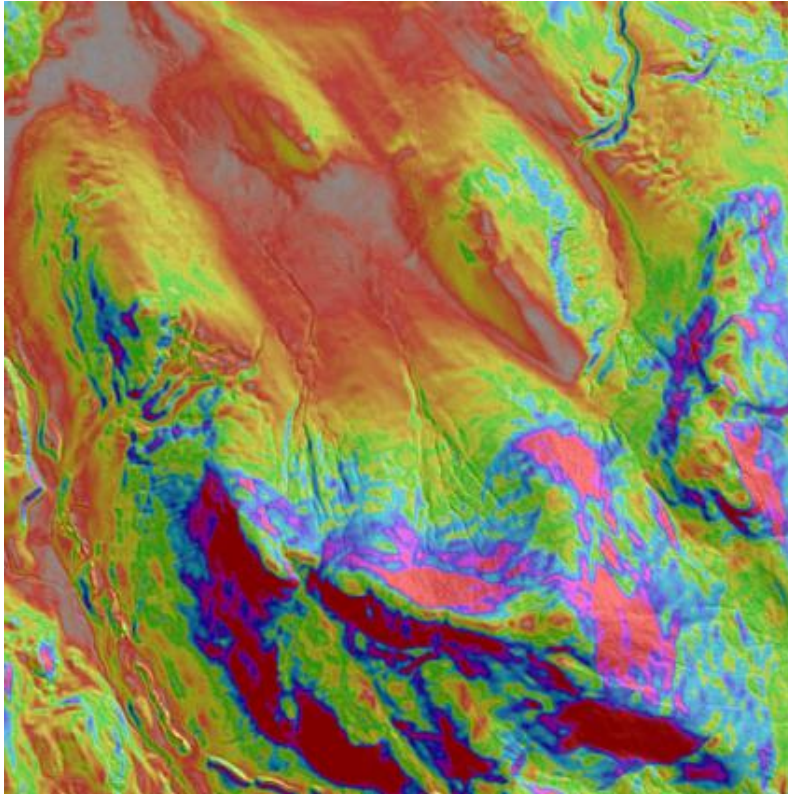
Elevation 200–600m
is typical for soil A.

As elevation
deviates from this
range, the soil's
similarity to type A
gradually decreases.

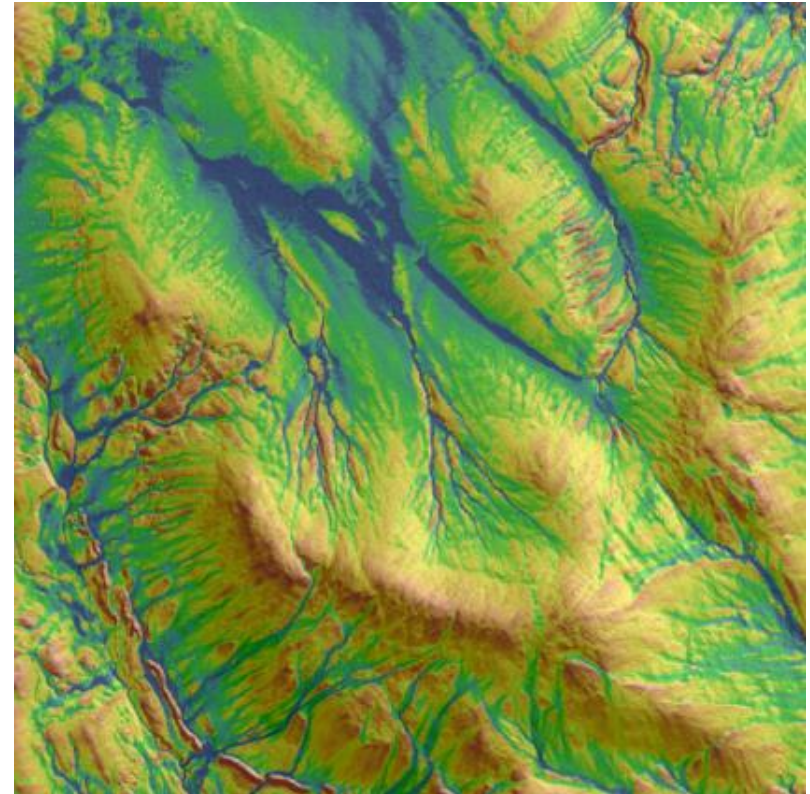




Terrain Derivatives



30m slope



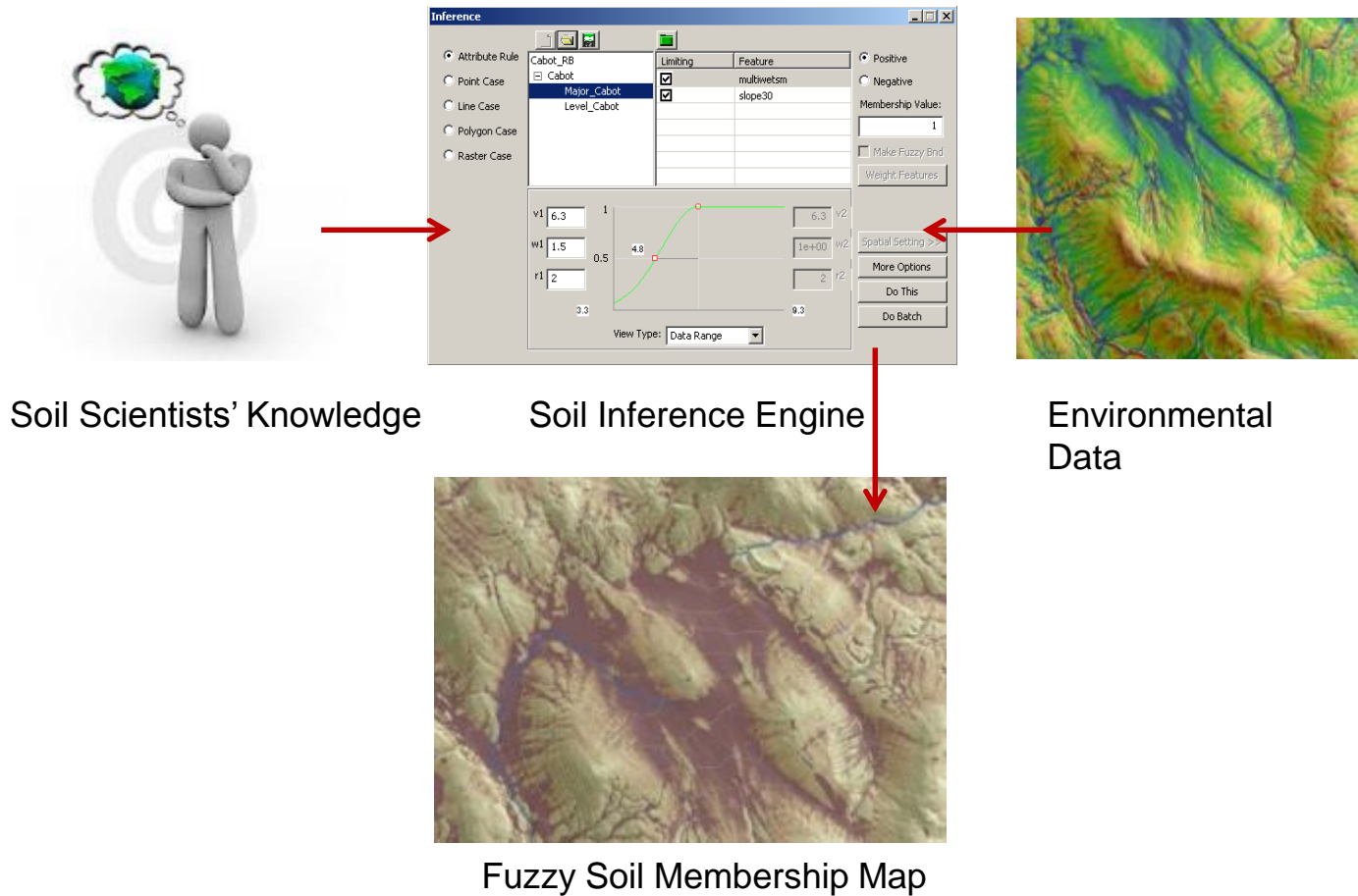
Multi-path smoothed wetness index

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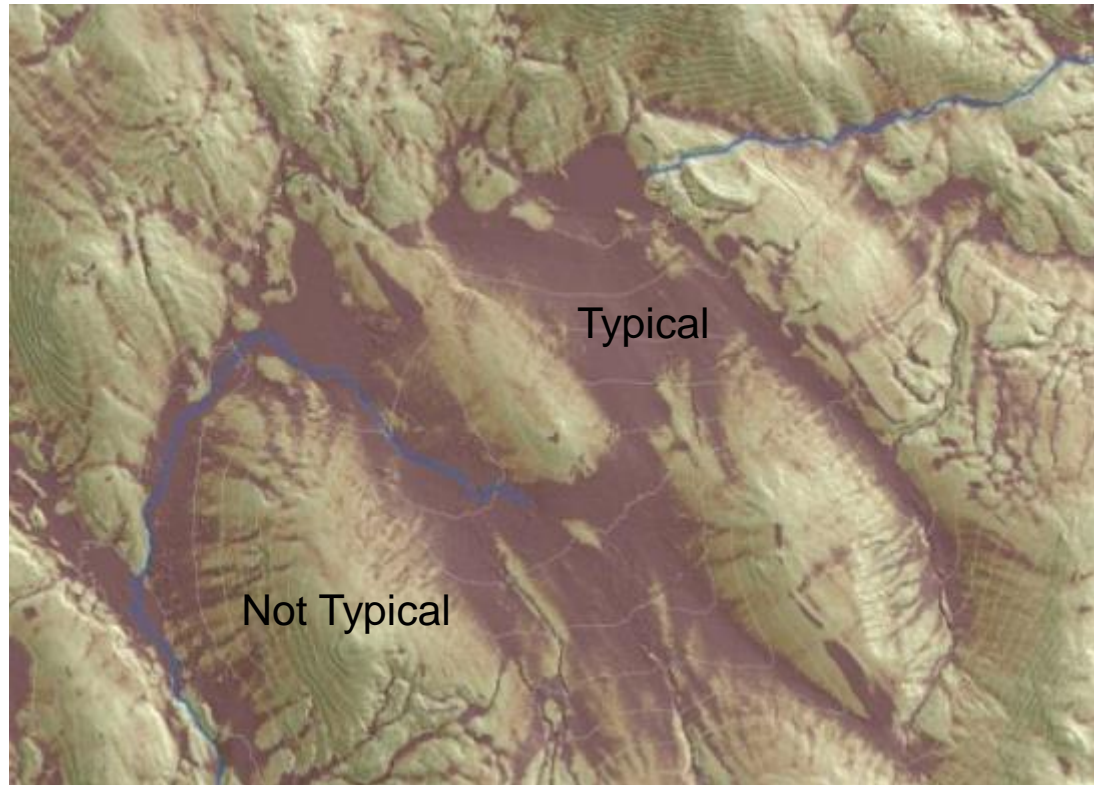
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Soil Inference Components

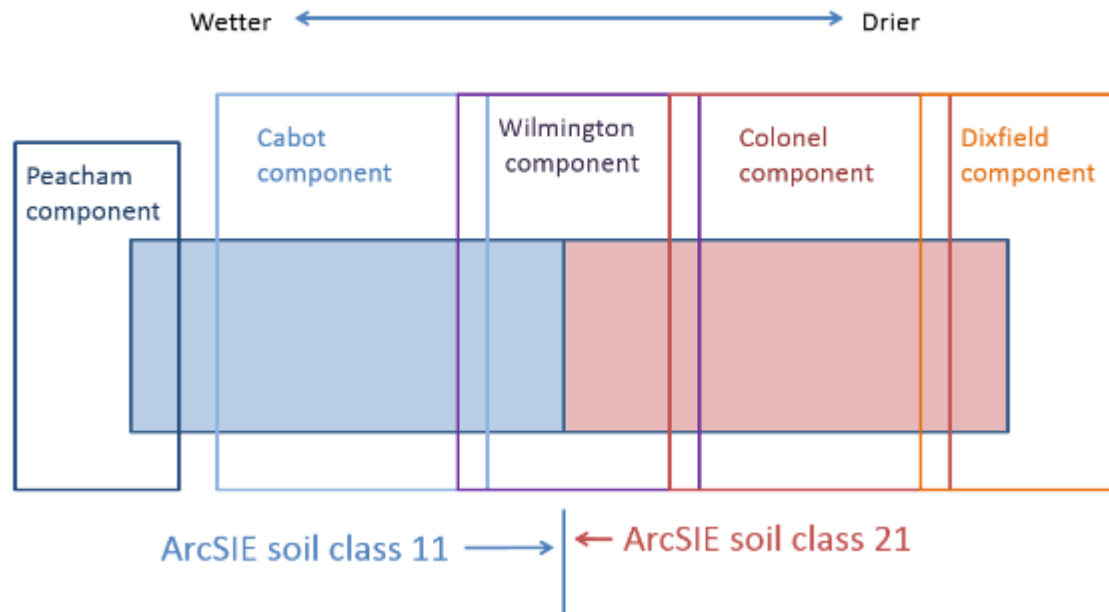


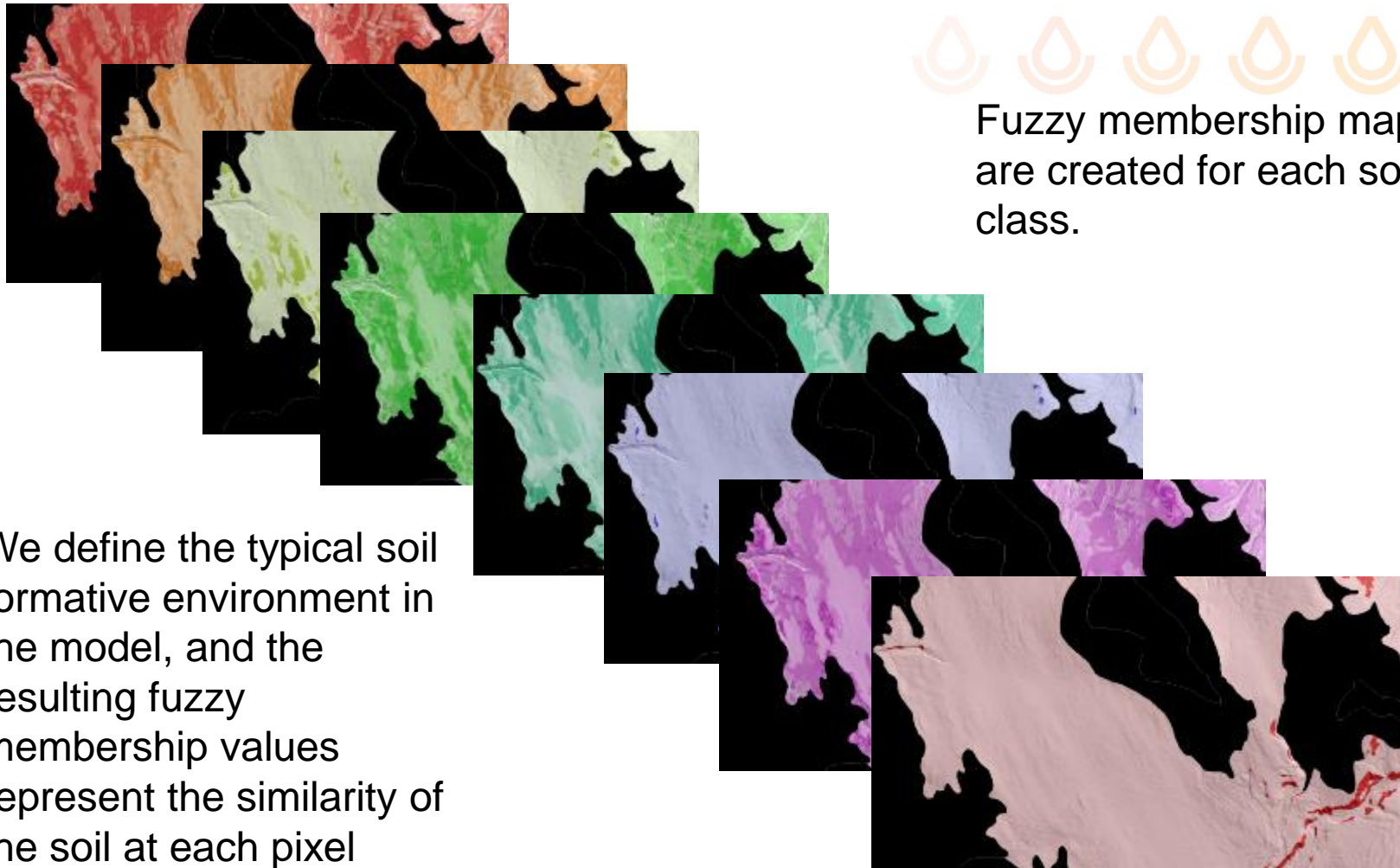
The fuzzy membership values represent the similarities of the pixel location to the typical soil formative environment.



What is a raster component?

- Maybe better termed a “soil class”. Defined specifically by soil characteristics and position on the landform, such as:
 11 – nearly level to gently sloping wet soils on footslopes and in depressions
 21 – nearly level to gently sloping somewhat poorly drained soils on footslopes
- The model is designed to cover a catena of soils, and each modeled soil component/class is not limited in definition to a single soil series.

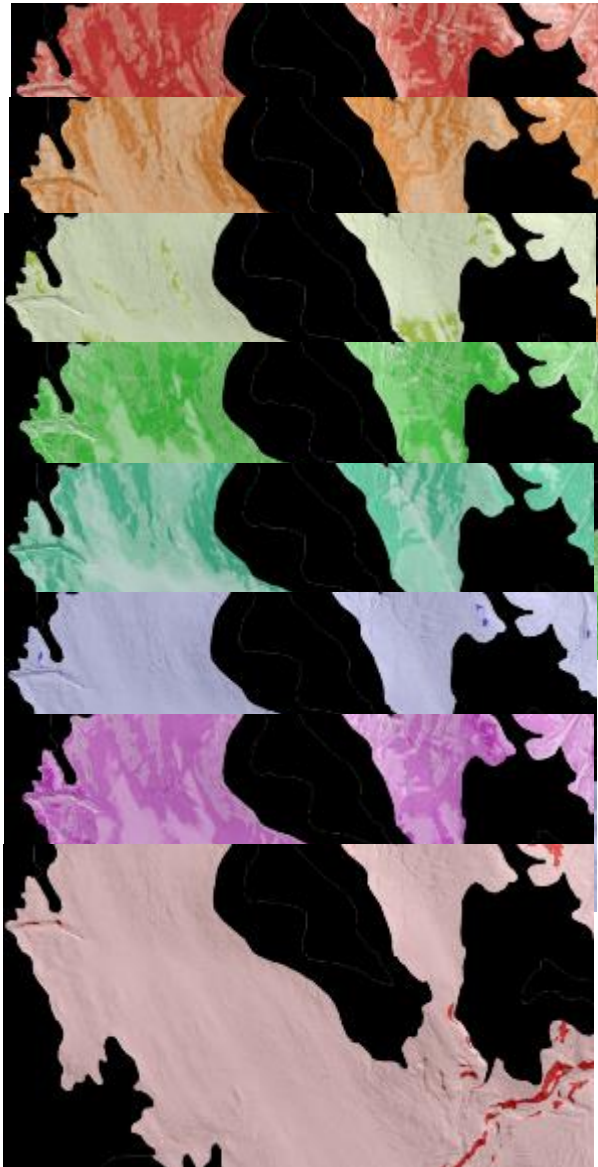




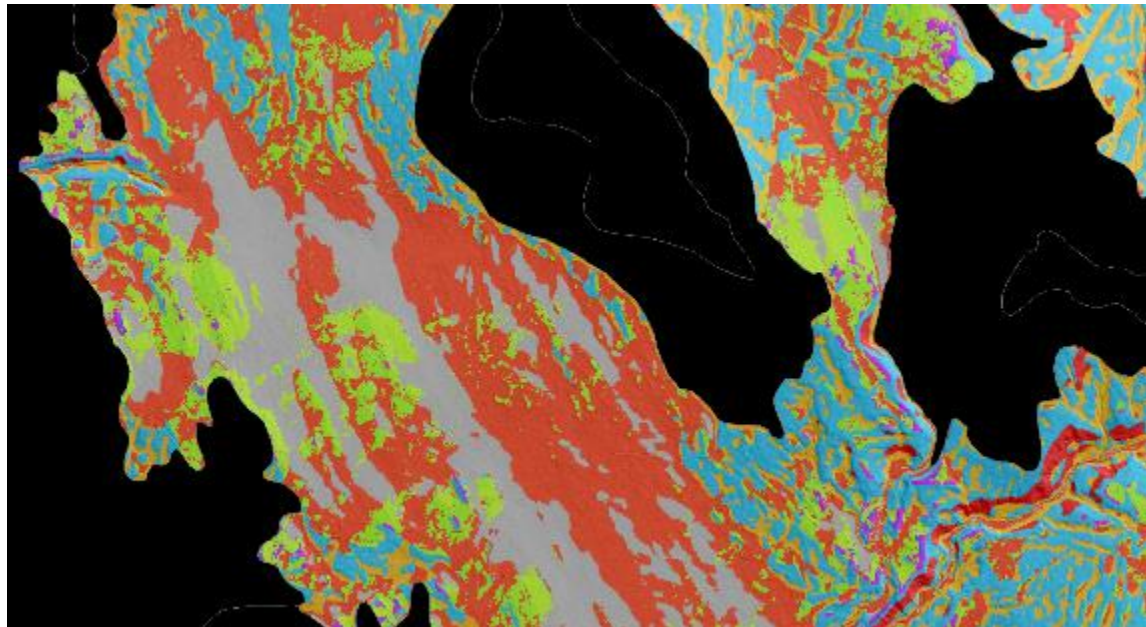
Fuzzy membership maps
are created for each soil
class.

We define the typical soil
formative environment in
the model, and the
resulting fuzzy
membership values
represent the similarity of
the soil at each pixel
location to a particular
soil class.



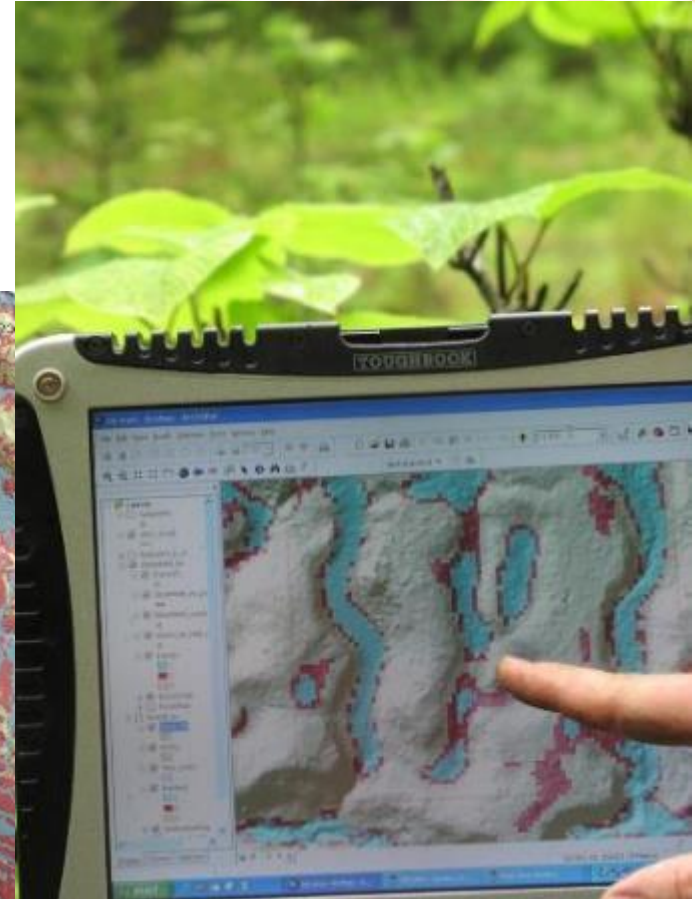


Hardening (Defuzzification)



Each pixel is assigned to the soil class with the highest fuzzy membership at that location.

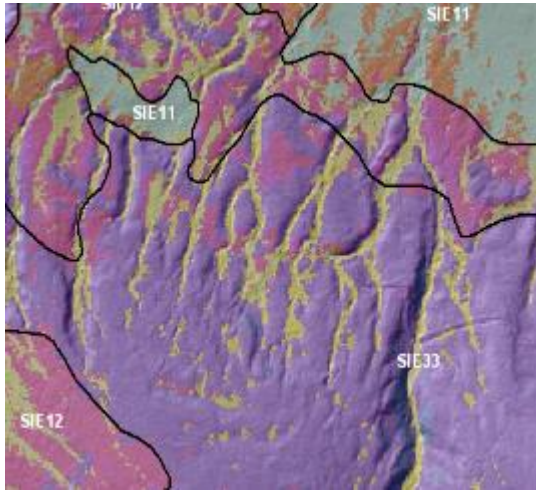
SIE Results are Validated in the Field



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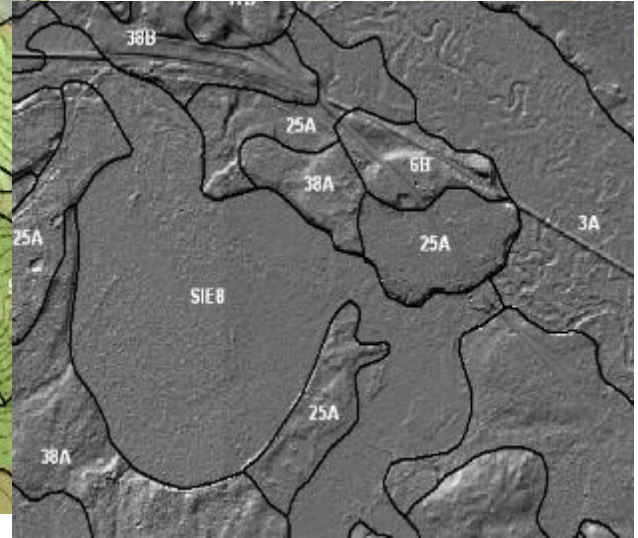




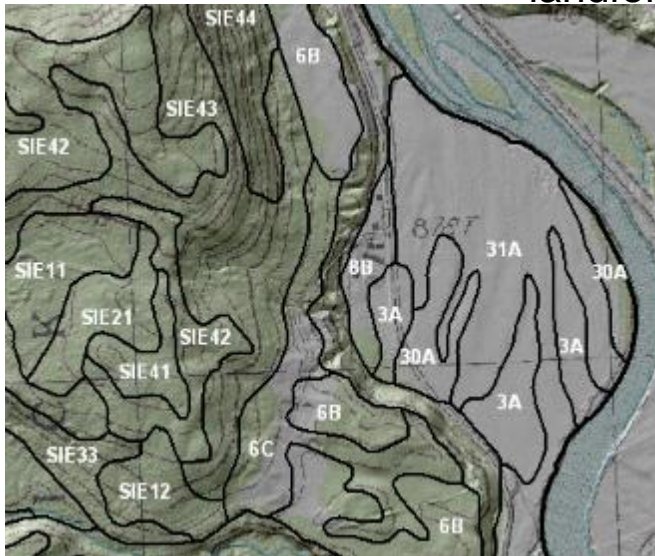
Predictive modeling by soil series



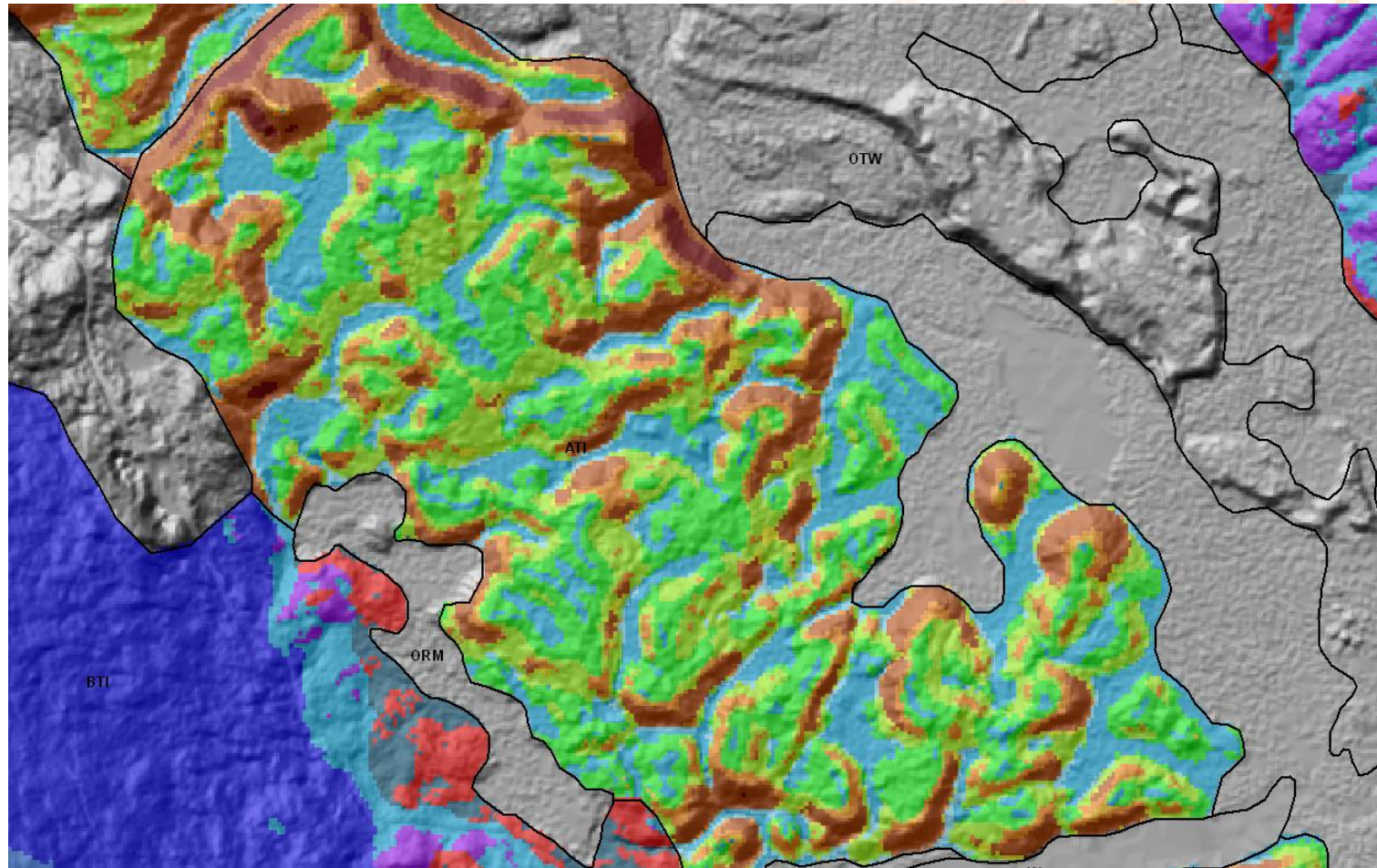
Brute force modeling by landform and slope class



Traditional mapping with modern enhancements



All **can** be combined to
create a SSURGO
product



The catena models allows us to visualize where different components occur within a “traditional” map unit.

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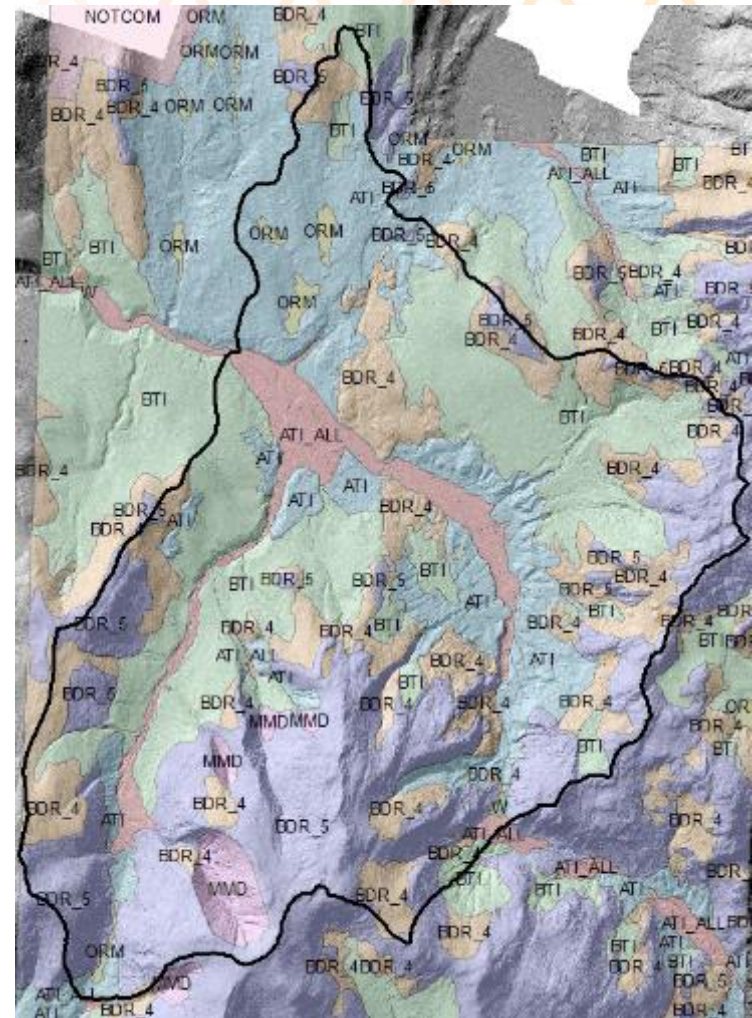
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Since 2010 – the focus has been on joint (USFS, UNH, and NRCS) soil, site, and vegetation investigations in the 17,000 acre upper Wild Ammonoosuc River watershed in the White Mountain National Forest.

This information is being used to develop models for soil survey (SSURGO), USFS Terrestrial Ecological Unit Inventory (TEUI), and NRCS Ecological Site Description (ESD)

Right: draft soil parent materials in upper Wild Ammo watershed

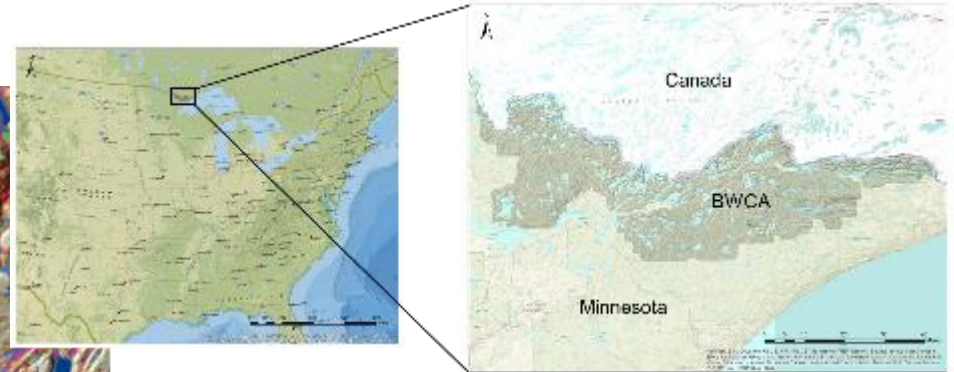
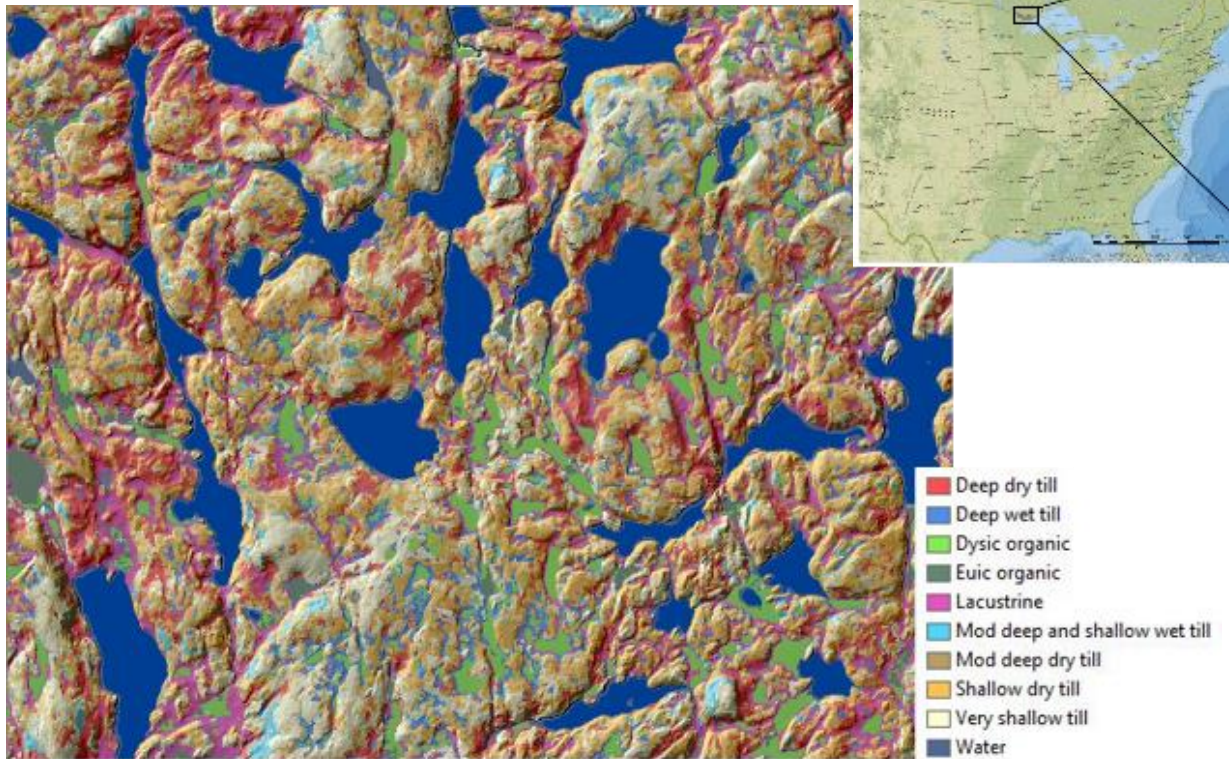


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The St. Johnsbury Soil Survey Office is part of a team charged with mapping soils in the Boundary Waters Canoe Area Wilderness in Minnesota



Knowledge-based modeling is being used in concert with logistic regression and random forests modeling to create the final raster soil map.

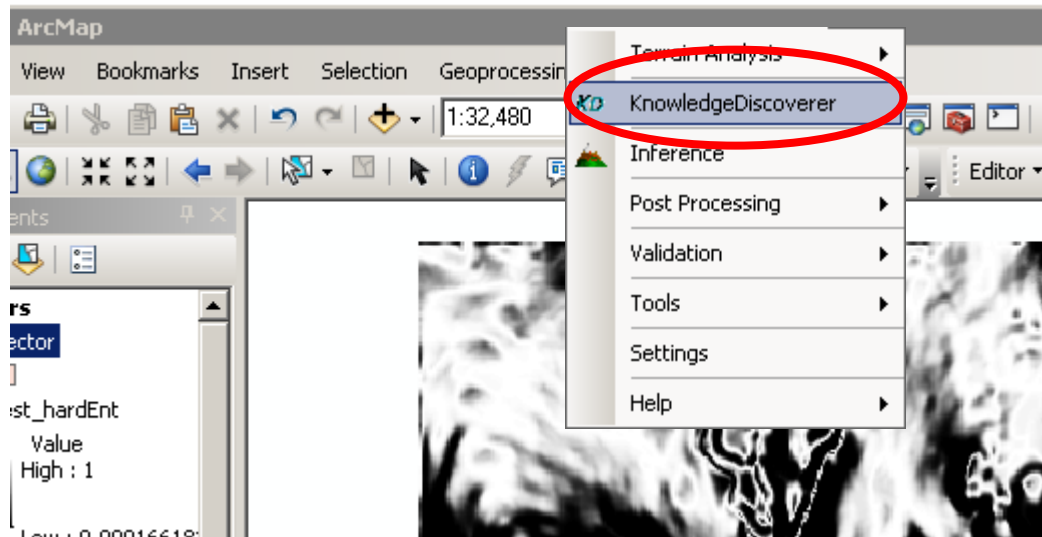
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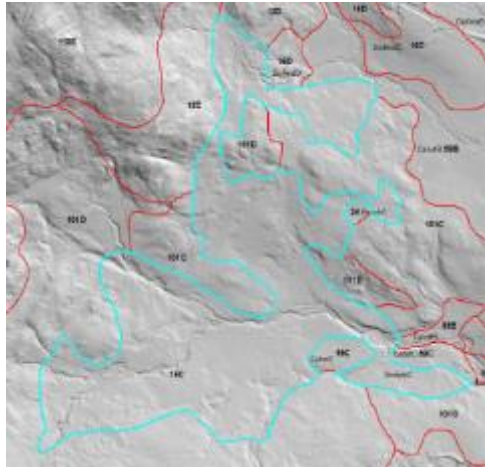
Knowledge Discoverer

A module in **ArcSIE** for soil survey update.

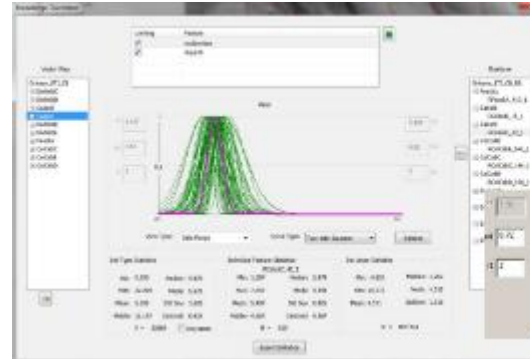
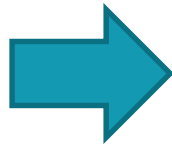


The approach is to *discover*, *revise*, and *reuse* the knowledge (soil-landscape model) implicitly represented by an existing soil map, during which it incorporates updated (better) knowledge and data.





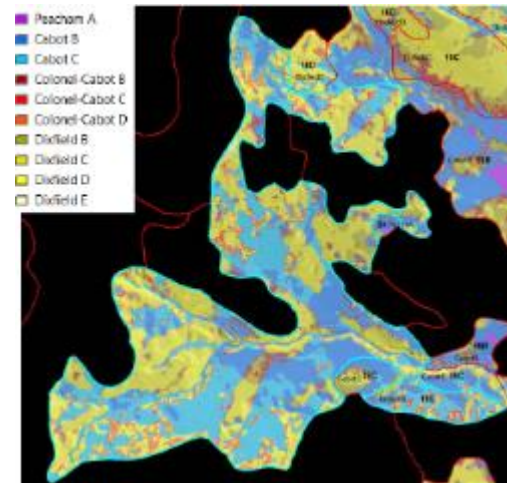
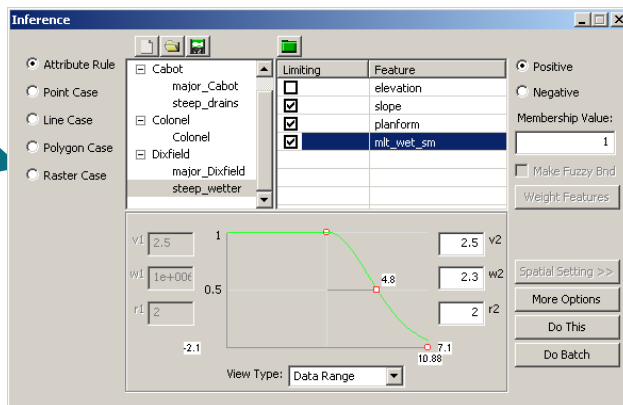
Original SSURGO polygon of Dixfield sandy loam, 8-15 percent slope



Knowledge Discoverer

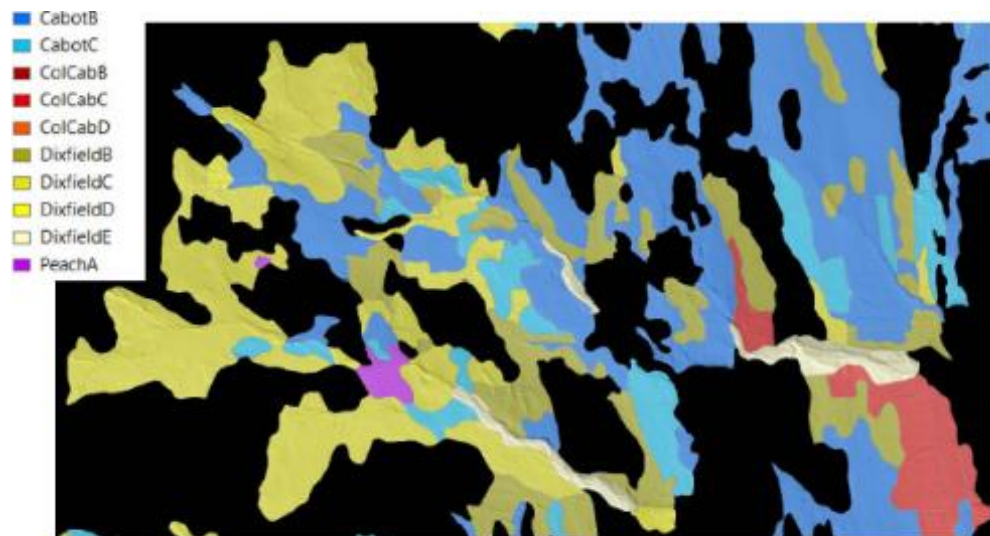
One “typical” curve was selected to represent each map unit, and edited according to new knowledge/better data (in this case LiDAR derivatives)

Soil Inference Engine



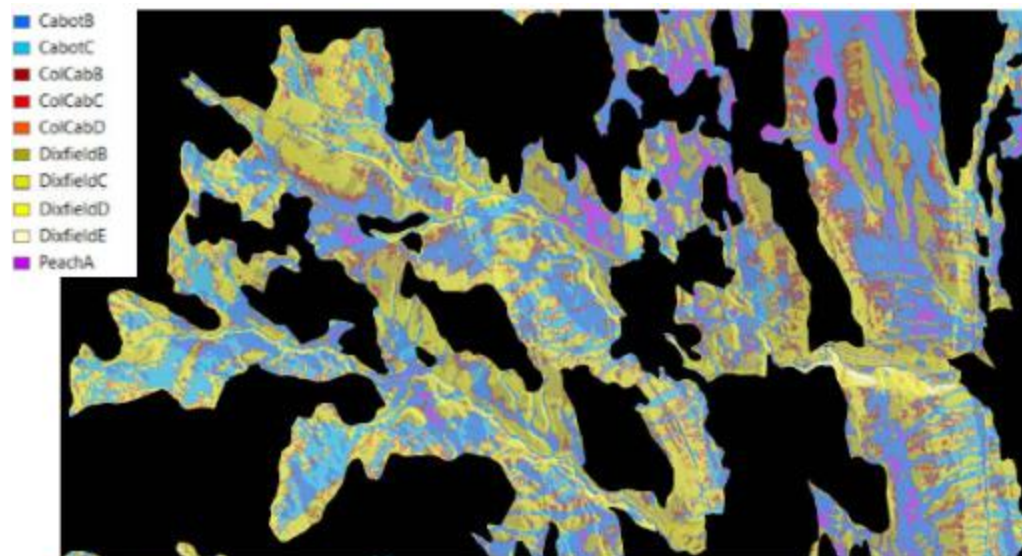
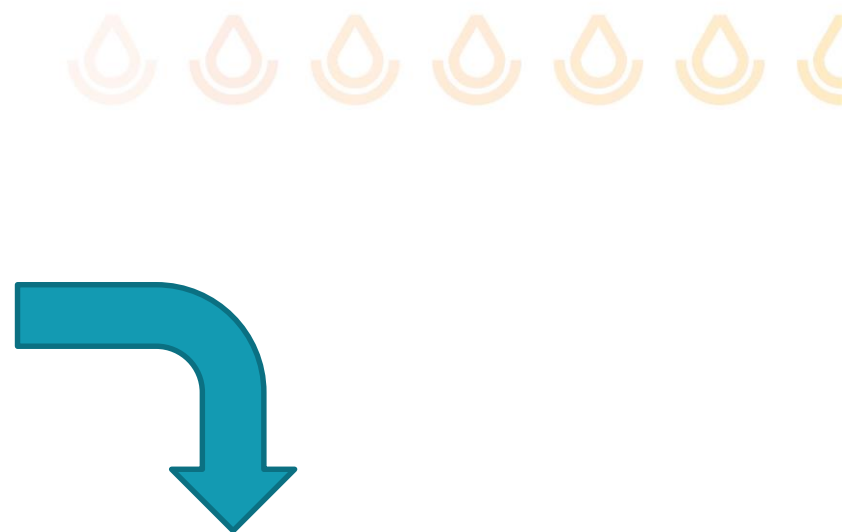
Updated map





1:24,000

SSURGO Polygon Map Units



1:24,000

Update Raster Map Units

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Thank You!



For more information, email me: Jessica.Philippe@vt.usda.gov

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